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ABSTRACT

An education and communication project of the Environment and Technology Assessment Program, Oak Ridge National Laboratory, Tennessee, is described in this report. The project for monitoring air dustfall resulted in the largest citizen-scientist air monitoring effort in the history of our nation. Nearly 21,000 public secondary school students and teachers through Tennessee were involved in the test during April, 1971. Primary goal was to establish a benchmark of basic data concerning air quality that would be useful in defining air quality standards. Sedimentation foils (over 20,700), coated with adhesive, were placed in open areas where they collected insoluable particles (dustfall) for a 30-day period. Results from weight gain analyses, in statistical and narrative form, together with operational procedures are presented in the report. (BL)

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VOLUNTEERS FOR AIR MONITORING PROJECT

(VAMP)

Sponsored by

THE COOPERATIVE SCIENCE EDUCATION CENTER, INC.

An Education and Communication Project

of

The Environment and Technology Assessment Program

at

THE OAK RIDGE NATIONAL LABORATORY

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Report No. 1 September, 1971

VOLUNTEERS for AIR MONITORING PROJECT (VAMP)

The Cooperative Science Education Center, Inc.
under subcontract to
Oak Ridge National Laboratory
Oak Ridge, Tennessee 37830

SUMMARY

The Volunteers for Air Monitoring Project (VAMP) has resulted in the largest citizen-scientist air monitoring effort in the history of our nation. Nearly 21,000 public secondary school students and their teachers across the state of Tennessee received monitors during late March, 1971. On April 1, these sedimentation foils, coated with adhesive, were placed in open areas where they collected insoluble particulates (dustfall) for a 30 day period. The weight gains for individual counties, in terms of tons per square mile, ranged from 3.8 to 13.4, with an average county gain of 6.6.

INTRODUCTION

There is no doubt that the 1970's are evolving into the Decade of Environmental Concern. With the interest generated by the public in the environment, sweeping changes have begun in governmental agencies. These changes are precipitating new goals and priorities. The opportunities for the individual to exercise his rights of citizenship in environmental planning and related problem areas are becoming more numerous because of the public hearings now required on numerous environmental matters. The Air Quality Act of 1967 requires that states hold public hearings on air quality standards. The citizen is being asked increasingly to take an active part in making environmental decisions.

The Cooperative Science Education Center (CSEC), in close cooperation with the Oak Ridge National Laboratory (ORNL), is interested in increasing citizen awareness and participation in environmental problem definition. The Volunteers for Air Monitoring Project (VAMP), which resulted in the largest

citizen-scientist air monitoring effort in the history of our nation, was almost wholly dependent upon citizen participation. The VAMP program enlisted the support of thousands of individuals representing public schools, industries, and volunteer groups in Tennessee. The analytical measurement of certain air pollutants was, of course, a primary objective in this study. The extensive participation of lay citizens was also a major objective as it has become necessary for the public to have an increased understanding of complex environmental problems in order to rationally assist the scientist and politician in improving environmental quality.

The Oak Ridge National Laboratory has been active in environmental studies for a number of years. During 1970, ORNL became involved in a new program entitled The Environment and Technology Assessment, which was funded under the IPRPOS (Interdisciplinary Research Relevant to Problems of Our Society) program, a new effort within the National Science Foundation. The CSEC, a non-profit regional educational corporation under a subcontract with ORNL, began the planning and development of an important program component -- Education and Communication. Environmental programs of an informative nature were made available to a target population including the general public and educators in the State of Tennessee as part of the CSEC subcontract responsibility. One of the ten activities emphasizing technology assessment that were implemented as part of the CSEC effort was the state-wide air quality monitoring project.

GENERAL CONCEPT

The primary goal of VAMP was to establish one benchmark of basic data concerning air quality that could be useful in defining air quality standards. A similar project of 5,000 monitors was completed in the Albany Capital District of New York State during April, 1969, under the direction of Dr. Volker A. Mohnen of the Atmospheric Science Research Center, State University of New York. Dr. Mohnen provided invaluable assistance in the early planning of VAMP.

There is no question that the air we breathe contains many particles and pollutants, such as natural pollens, dust, carbon monoxide, sulfur dioxide, hydrocarbons, and countless compounds of varying significance. These pollutants that are particles range in size from one millionth of an inch to about one fortieth of an inch. In air quality technology this phenomenon is termed the atmospheric particle size distribution. The larger the particle is, the larger is its individual mass and, therefore, the faster it will settle. This explains in part an important atmospheric cleansing process called sedimentation.

The air monitoring device we chose to use is called a "sedimentation foil". This standard monitoring technique was first used by British hygienists in 1878 for measuring dust sedimentation in London. Our monitor consisted of a one 5000th of an inch thick aluminum foil, 1-5/8" x 3", which was coated with a non-drying silicone adhesive (General Electric SR 516). The foil was placed in a sample holder or guard to protect it from contamination by birds and wind damage. The major advantage of this method was in its simplicity with regard to the experimental procedure and the extraction of raw data. The cost of a more sophisticated device for such extensive monitoring would have been prohibitive. With the established values of the sedimentation foil technique verified through past studies, we were reasonably assured of the reliability of this monitoring technique.

OPERATIONAL PROCEDURES

Preliminary planning for VAMP was announced in September, 1970, in the Environmental Capsule, a monthly publication of the CSEC that is distributed to every school and many other lay citizens in Tennessee. Since the monitoring was to be a volunteer citizen project, industries within the state were requested to participate by donating labor, advice, or materials. There was a good response. The Aluminum Products Sales, Reynolds Aluminum Company, Nashville, provided a reduced price in the purchase of aluminum for both foil and sample holder (guard).

The Jim Robbins Seat Belt Company (Southern Automotive Division, Allied Chemical Corporation), provided many hours of labor in fabrication of the monitor guards. The General Electric Corporation loaned the use of their dies for guard fabrication. The Union Carbide Corporation donated individual plastic bags to enclose each monitor. The Container Division, Union Camp Corporation, Morristown, donated six hundred corrugated boxes for shipping the monitors to the respective schools. Benco Plastics, Incorporated, Knoxville, provided technical assistance throughout the period of project development.

While industry was being contacted during the months of November and December, Regional Environmental Awareness conferences were held in Oak Ridge, Kingsport, Chattanooga, Nashville, Jackson, and Memphis. The regional conferences served several functions: (1) To gather information on environmental problems of concern to the citizens and, (2) To permit dialogue with scientists actively engaged in environmental research at ORNL. These conferences also provided an opportunity to explain the total education and communication program including the VAMP program.

During November, the state Commissioner of Education endorsed VAMP as a statewide public school project, and in early December introductory information was sent to all public school superintendents for approval within their respective systems. In January, all public secondary school principals were contacted by letter and requested to return a card designating one or more of their teachers as a VAMP Coordinator. We were most encouraged by the responses of the administrators and teachers throughout the state.

As cards were returned from the schools, the coordinators were sent packets designating a specific number of air monitors for their school and sample instructions for their review before the monitors arrived on the site. The Tennessee Tuberculosis and Respiratory Disease Association provided a variety

of educational materials for each school, which were enclosed with the preliminary review materials. The CSEC prepared a list of books, films, and activities for the teacher to use in creating student interest prior to the arrival of the monitors.

During communications with the public schools, volunteers and CSEC staff members were processing, coding and weighing each individual foil. The aluminum stock arrived at the Center in two 36-inch rolls and from this 26,000 strips approximately 1-5/8" x 3" were cut to serve as the sedimentation foils. A single hole was punched in the end of each strip and a number was imprinted with a dry ball point pen. The preparation of the foils was a laborious task, and we were grateful to have volunteers from the area Boy Scouts of America, Campfire Girls, regional schools, YWCA, American Association for Retired Persons, Environmental Council of Oak Ridge, and the area chapter of the League of Women Voters.

There were numerous hours of labor spent in individually applying the silicone adhesive to each foil. Because of volatile toluene solvent fumes associated with the adhesive, CSEC staff members coated all foils. Large 3' x 6' pieces of tri-wall cardboard were studded with sheetrock nails. The surface of the cardboard was covered with waxed paper to prevent excess adhesive from adhering to the cardboard. The coated foils were hung vertically and left to dry for 24-48 hours in a CSEC laboratory which had been carefully sealed to prevent dust from settling on the foils.

Previous use of this technique by others indicated that preliminary weighing of the coated foils to the nearest milligram would produce statistically significant information. Following the weighing, the foil was immediately inserted in the guard. Frequent checks of both the analytical balances and reweighing of randomly selected foils provided weighing control. The precut hold-down tabs of the guards were folded over the sedimentation foils with modified stainless steel pliers.

The monitors were then enclosed in plastic bags which were sealed and placed in individual boxes with the monitor number recorded on the box. The completed monitor packages were then grouped in lots of one hundred and stored temporarily prior to shipment to the respective schools. Each foil-frame assembly required 24 distinct hand operations exclusive of the metal guard fabrication.

The monitors were divided into allotments according to population density. It was agreed that, based on 1960 U.S. census figures, urban areas would receive the largest number of monitors. There were twenty-six urban centers, with populations varying from 620,000 down to 10,000, included in the state monitoring project in addition to the 95 counties. Each participating county received a minimum of 35 monitors. Shipments were made to 314 secondary schools during March, 1971.

The primary responsibilities of the VAMP coordinator at each school were the distribution of the monitors to students, encouragements of a random placement of the monitors, and the collection of materials for return to CSEC. With few exceptions the coordinators accomplished their assignment and many extended the VAMP activity to more detailed studies of the local community so as to insure a more representative sampling of their area. All students, however, were directed to place the monitor in their yards away from trees or any large man-made structures.

After the distribution of monitors and instructions for installation, on April 1, the students fastened their monitors to a pole or post, approximately four and one-half feet above the ground, and thus began the month-long monitoring period. Each student participant had been issued a weather chart coded for weather conditions which they were instructed to record daily, with specific emphasis on all forms of precipitation. At the conclusion of the monitoring period on April 30, the coordinators collected the monitors and weather sheets from the students and returned them to the CSEC for weight analysis.

RESULTS AND DISCUSSION - WEIGHT ANALYSIS

The summary of monitors sent and returned is given in Table I. Nearly 87% of the schools returned monitors, with over 80% of the individual monitors being received. These figures indicate a high enthusiasm for the project by the students and the coordinators.

TABLE I

Monitor Summary

		Percent of Total
Total rumber of monitors sent (314 schools)	20,774	
Number of monitors returned (273 schools)	16,770	80.7
Number of information sheets returned	11,571	55.7
Number of monitors judged valid	5,319	25.6

The decision was made to reject monitors that were not accompanied by an information sheet since this would mean that weather conditions, monitor location, etc., would not be available, and no assurance would be provided that these monitors had even been exposed. Each record sheet was reviewed to establish if that monitor was disturbed and if so, to what degree. If the student indicated that the monitor was knocked to the ground or vandalized, the foil was declared invalid.[1] Heavy winds in West Tennessee during this period resulted in many monitors being disturbed or completely destroyed.[2] Each remaining monitor was inspected and some were voided due to obvious accumulations of grass, gravel, bird waste, etc.

Each foil that was declared valid by this multiple inspection was then reweighed. The weight gains were recorded to the nearest milligram (mg.). In general, the gains were of the order of 5 to 25 mg. Some foils were declared invalid at this point as they showed no weight gain, and did not appear to have been exposed, expecially if all other foils for that particular school showed gains.

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[1]The reporting of "cows stepping on the monitor" and "my dog chewed it up" are indicative of the descriptive accounting of monitors.

[2]The winds and accidental damage to monitors by cattle were the predominant factors for invalidation of monitors.

A few foils showed extremely high gains, a factor of 5 or 6 higher than the next highest foil at that school. Reinspection of the record sheets sometimes gave a possible explanation, such as installation near a dusty road, under a tree, etc., and these foils were rejected.

TABLE II

Distribution of County Weight Gains

RANK I

Range (tons per square mile)	Number of Counties
3 - 4	3
4 - 5	16

RANK II

Range (tons per square mile)	Number of Counties
5 - 6	21

RANK III

Range (tons per square mile)	Number of Counties
6 - 7	15

RANK IV

Range (tons per square mile)	Number of Counties
7 - 8	14

RANK V

Range (tons per square mile)	Number of Counties
8 - 9	12

RANK VI

Range (tons per square mile)	Number of Counties
9 - 10	3
10 - 11	1
11 - 12	1
12 - 13	2
13 - 14	1

TABLE III
County Ranks and Sample Sizes

County	Number of Valid Monitors	Rank	County	Number of Valid Monitors	Rank
Anderson	92	I	Lauderdale	47	VI
Bedford	37	IV	Lawrence	20	II
Benton	16	V	Lewis	38	I
Bledsoe	41	II	Lincoln	13	III
Blount	47	III	Loudon	32	II
Bradley	110	II	McMinn	22	II
Campbell	35	I	McNairy	33	V
Cannon	17	III	Macon	18	VI
Carroll	14	IV	Madison	82	VI
Carter	95	I	Marion	32	V
Cheatham	20	I	Marshall	13	V
Chester	34	IV	Maury	97	V
Claiborne	41	II	Meigs	0	-
Clay	0	-	Monroe	25	I
Cocke	38	II	Montgomery	46	IV
Coffee	72	IV	Moore	31	II
Crockett	6	V	Morgan	10	III
Cumberland	0	-	Obion	37	V
Davidson	513	IV	Overton	39	IV
Decatur	28	III	Perry	0	-
Dekalb	17	III	Pickett	36	I
Dickson	13	II	Polk	54	V
Dyer	19	IV	Putnam	89	II
Fayette	30	VI	Rhea	43	III
Fentress	45	II	Roane	32	IV
Franklin	23	IV	Robertson	12	I
Gibson	66	VI	Rutherford	42	II
Giles	16	VI	Scott	42	I
Grainger	44	II	Sequatchie	11	IV
Greene	89	I	Sevier	19	I
Grundy	14	II	Shelby	865	VI
Hamblen	41	II	Smith	39	II
Hamilton	298	V	Stewart	16	III
Hancock	32	I	Sullivan	160	III
Hardeman	19	IV	Sumner	43	III
Hardin	30	V	Tipton	17	V
Hawkins	36	II	Trousdale	20	I
Haywood	0	-	Unicoi	28	I
Henderson	7	IV	Union	38	II
Henry	17	IV	Van Buren	36	II
Hickman	26	I	Warren	75	I
Houston	34	III	Washington	58	I
Humphreys	24	II	Wayne	8	III
Jackson	25	I	Weakley	37	V
Jefferson	28	III	White	41	III
Johnson	0	-	Williamson	36	I
Knox	465	III	Wilson	48	II
Lake	25	VI			

The weight gains for each valid foil were converted to tons per square mile, based on an average foil size of 4.875 square inches. The values for individual foils ranged from essentially zero to over 100 tons per square mile. Since the total number of valid foils from some schools was small, we felt it was inappropriate to calculate average weight gains by schools and instead we calculated averages by counties with 89 counties being represented. Insufficient valid samples were available from Clay, Cumberland, Haywood, Johnson, Meigs, and Perry counties. The average weight gains in terms of tons per square mile for the month of April, 1971, ranged from 3.8 to 13.4, with an average county gain of 6.64.

Table II gives the distribution of weight gains for the counties (also see Figure 1). Most of the weight gains fell between 4 and 9 tons per square mile. The total weight gained by the entire state was approximately 280,000 tons.

Table III lists the counties alphabetically together with the number of valid monitors and the county rank, as defined by Table II. The eight counties having weight gains greater than 9 tons per square mile were Fayette, Gibson, Giles, Lake, Lauderdale, Macon, Madison, and Shelby. We felt it was statistically unsound to further rank these eight counties. Several of the high ranking counties are considered primarily agricultural and it is likely that dust from newly plowed fields was a large contributing factor.

Chemical analysis of the foil residues is still in process at Oak Ridge National Laboratory. A second report describing these findings will be released in the near future.

The VAMP study was intended to measure only those insoluble particulates (dust, etc.) that were not dissolved and hence washed off the foils by rainfall. Thus the values obtained are low with respect to the total dust fall that might be expected to occur in a given locality. The Tennessee ambient air quality standard for all particulate matter, both soluble and insoluble, in residential and agricultural areas is 17 tons per square mile for a 30-day period. The average monitor gain in the VAMP study of 7.56 is only 44% of this standard. The results of the Albany,

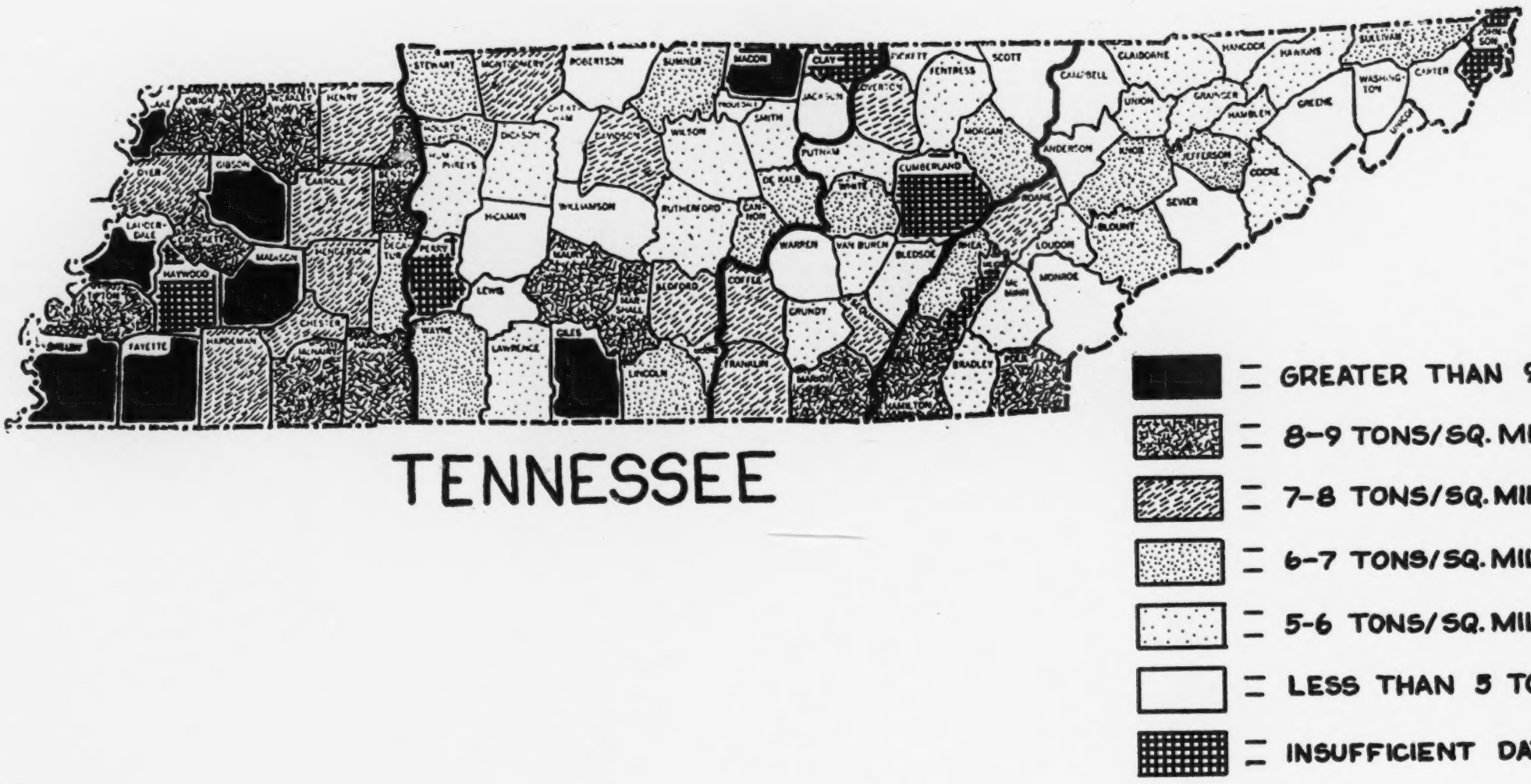
New York, study showed an average weight gain by 12.6 tons per square mile in an industrialized urban area.

Comparison of the VAMP data for Anderson County shows good agreement with other dust fall samples analyzed for insoluble inorganic particulates by the Atomic Energy Commission in Oak Ridge, thus strengthening our belief that the VAMP project did yield a reasonably accurate picture of one parameter of air quality in Tennessee for a given time period. It is expected that a study made at a different time of year might yield substantially different results.

We have not attempted to answer all the questions concerning air quality in Tennessee, but we have demonstrated that the lay citizen is concerned enough about his environment to assist in an extended investigation. Such participatory experimentation provides a useful and low cost means of further defining complex environmental problems. The process of the investigation becomes a learning experience for those involved while the data derived is of practical use to the scientific community. This conscientious effort on the part of teachers and students has established the basis for other cooperative projects between the lay citizen and the laboratory scientist.

FIGURE 1. INSOLUBLE PARTICULATES (DUST FALL)
FOR APRIL 1971 (VAMP RESULTS)

Dark Lines Separate Four Proposed
Air Quality Control Regions


TENNESSEE
= GREATER THAN 9 TONS/SQ. MILE
= 8-9 TONS/SQ. MILE
= 7-8 TONS/SQ. MILE
= 6-7 TONS/SQ. MILE
= 5-6 TONS/SQ. MILE
= LESS THAN 5 TONS/SQ. MILE
= INSUFFICIENT DATA